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SUMMARY REPORT ON THE WHITE SPRUCE SAWFLY IN THE GASPE PENINSULA IN 1932

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INTRODUCTION.

The white spruce sawfly (Diprion polytomum (Hartig) has been known in Europe as a defoliator of spruce for a hundred years. It has, however, never been reported as doing serious damage there.

In the fall of 1930, defoliation of white spruce by a sawfly was discovered at several points in the interior of the Gaspe and this was investigated the following year. Careful study of the insect and comparison with other specimens at the United States National Museum and the British Museum established the fact that it was the species Diprion polytomum. This was the first record of its occurrence in America and it seems probable that it has been imported into Canada in comparatively recent times, possibly in moss used as packing.

If this is so, however, the sawfly has established itself over a very large area before becoming numerous enough to be conspicuous. In 1931, an aerial survey showed that it was present in destructive numbers throughout the greater part of the peninsula. There is no evidence in its distribution to indicate a point of entry. It is possible that it may exist in small numbers in other parts of eastern Quebec or the Maritimes.

The main results of the investigation in 1931 were given in a summary report by Mr. L. J. Simpson. In 1932, owing to the large area of forest attacked, and the fact that the species was known to be European and therefore possibly a very serious danger, the investigation was continued more intensively. A camp was established on Berry Mountain Brook, a tributary of the Grand Cascapedia River (marked Kelly's Camp on the map), and a close study of the conditions in the heart of the infestation was made in this area. At the same time, inspections were made at different points throughout the Gaspe. Mr. Simpson was in charge of the camp and general survey; Mr. M. L. Prebble in charge of the biological investigations.

The Entomological Branch wishes to acknowledge the material assistance rendered in many ways by the

Quebec Forest Service. The Quebec Forest Industries Association, Ltd., has assisted in keeping us in touch with the companies owning limits in the area. The continued co-operation of these companies has been of great help in collecting data, particularly the Hammermill Paper Company, the New Brunswick International Paper Company, and the Cascapedia Manufacturing and Trading Company.

The following report summarizes the results of the work which are of chief importance at the present time.

METHODS. The biology of the insect, including its life history, habits, development, host preferences, powers of reproduction, and the factors of natural control have been studied experimentally in the field and in the laboratory.

An attempt has also been made to study the sawfly population quantitatively in order to discover more accurately the degree of infestation in relation to damage, the proportionate value of controlling factors and the probable trend of the outbreak. This work has been concentrated on the cocoon stage in the ground and samples have been taken on plots of 100 x 100 feet in the Cascapedia area. The method used has been to examine thoroughly all the ground over areas of 2 x 2 feet, down to mineral soil, and record the numbers of cocoons containing living larvae, containing dead larvae, larvae eaten by shrews and other predators, and from which flies have emerged (see drawings). These 4-square-foot samples are taken every 20 feet, and repeated every spring and fall, Emergence and mortality records are then taken from the good cocoons collected on the plots each year.

As a check on conditions in other parts of the area, random samples of similar size have been taken wherever inspections were made. Notes on the type of stand, degree of damage, etc., were made at the same time. The interested companies have co-operated with us in taking these samples on their limits and sending the cocoons to us for analysis.

While the data have not yet been completely analyzed, owing to the time at which fall samples were taken as a result of the retarded season, their general significance has been determined.

The damage caused to date has been estimated from strip cruises made in the Berry Mountain Brook area.

THE INSECT. During the winter the insects are found in the ground as green, full grown larvae within brown, more or less oval-shaped cocoons, about 9x4 mms. in size. These are mostly in the moss or just under the moss above the soil. In the spring the larvae pupate and emerge as flies, after chewing a neat hole in the end of the cocoon. Emergence may commence in the Gaspe by the middle of June but the majority come out during July.

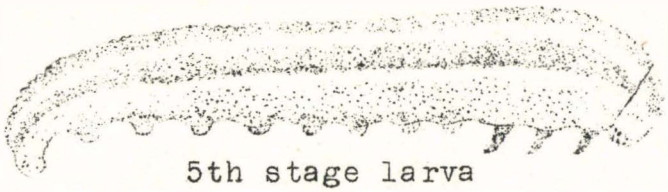
There are no males and therefore mating is not necessary. Shortly after emergence the flies start to lay eggs singly in slits in the needles, using the saw at the tip of the abdomen, from which the sawflies receive their name.

The eggs hatch in about two weeks and small, pale green, caterpillar-like larvae commence to eat out pieces of the needles. Later, the whole needle is consumed. As the larvae grow, they moult five times. All stages are green with a yellowish-brown head, but the fifth has five white lines along the body. The sixth stage does not feed but drops to the ground and spins its cocoon. It is marked with broad stripes of light and dark green and has no white lines.

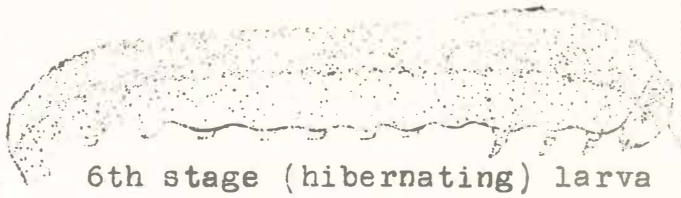
This dropping of mature larvae begins around the end of August and may continue until late in October. It is greatest around the end of September. During the past season, owing to the unusually cool spring and summer, the whole life history was retarded and a number of larvae were caught by early snow and frost, particularly at higher elevations.

ITS EFFECT ON THE TREE. Both white and black spruce are fed on. In the earlier stages of the outbreak some preference for white spruce was shown but during the last two years black spruce has been attacked with equal severity. There is a preference for the foliage of the year or so previous, but all old foliage is freely eaten. The new foliage is seldom eaten in the forest although larvae have been reared successfully in the laboratory on nothing but new growth.

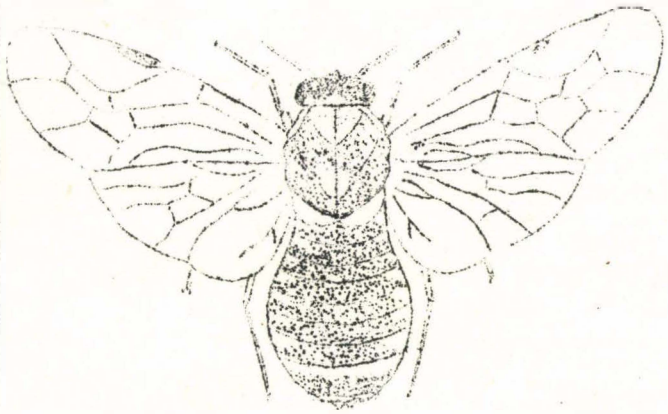
We do not know when the present outbreak commenced but the indications are that it had at least started in many white spruce stands in 1928. In 1930, many of the trees had lost about 75 per cent of their old foliage. The following year they put out very fair growth but the old foliage was almost all destroyed on many of the trees. In 1932, these trees again put out very fair needle growth but lost their 1931 foliage. At the end of the season such trees were practically all living and apparently capable of recovery, except where they had been attacked by bark-beetles. Here and there a tree was dying without barkbeetle attack, but these were isolated cases.



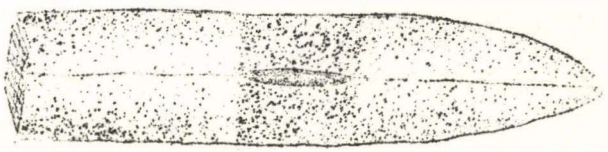
5th stage larva



6th stage (hibernating) larva

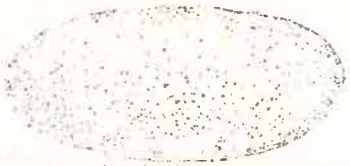


Adult sawfly

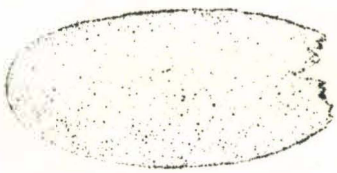


Egg laid in needle

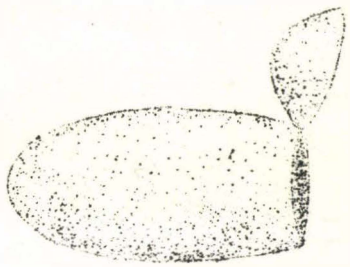
Cocoons.



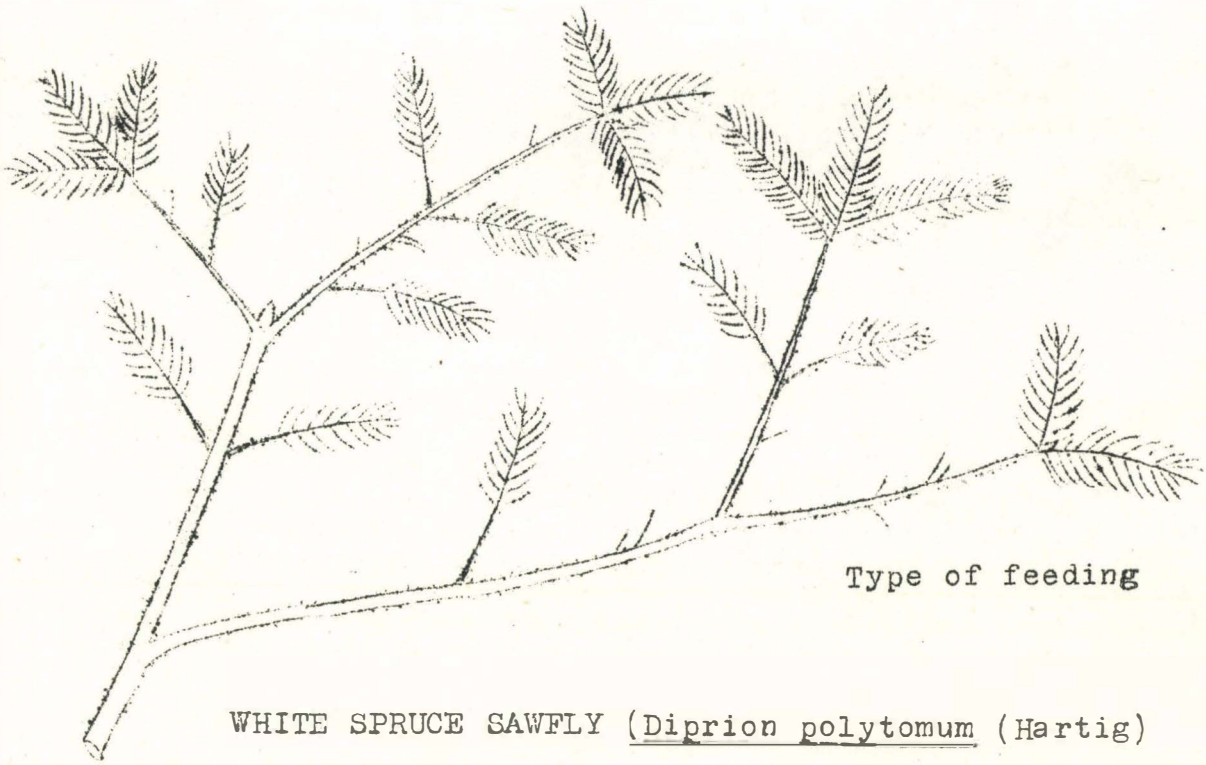
Containing larva



Eaten by shrews



Fly emerged



Type of feeding

WHITE SPRUCE SAWFLY (Diprion polytomum (Hartig)

(Approximate Scale: X6)

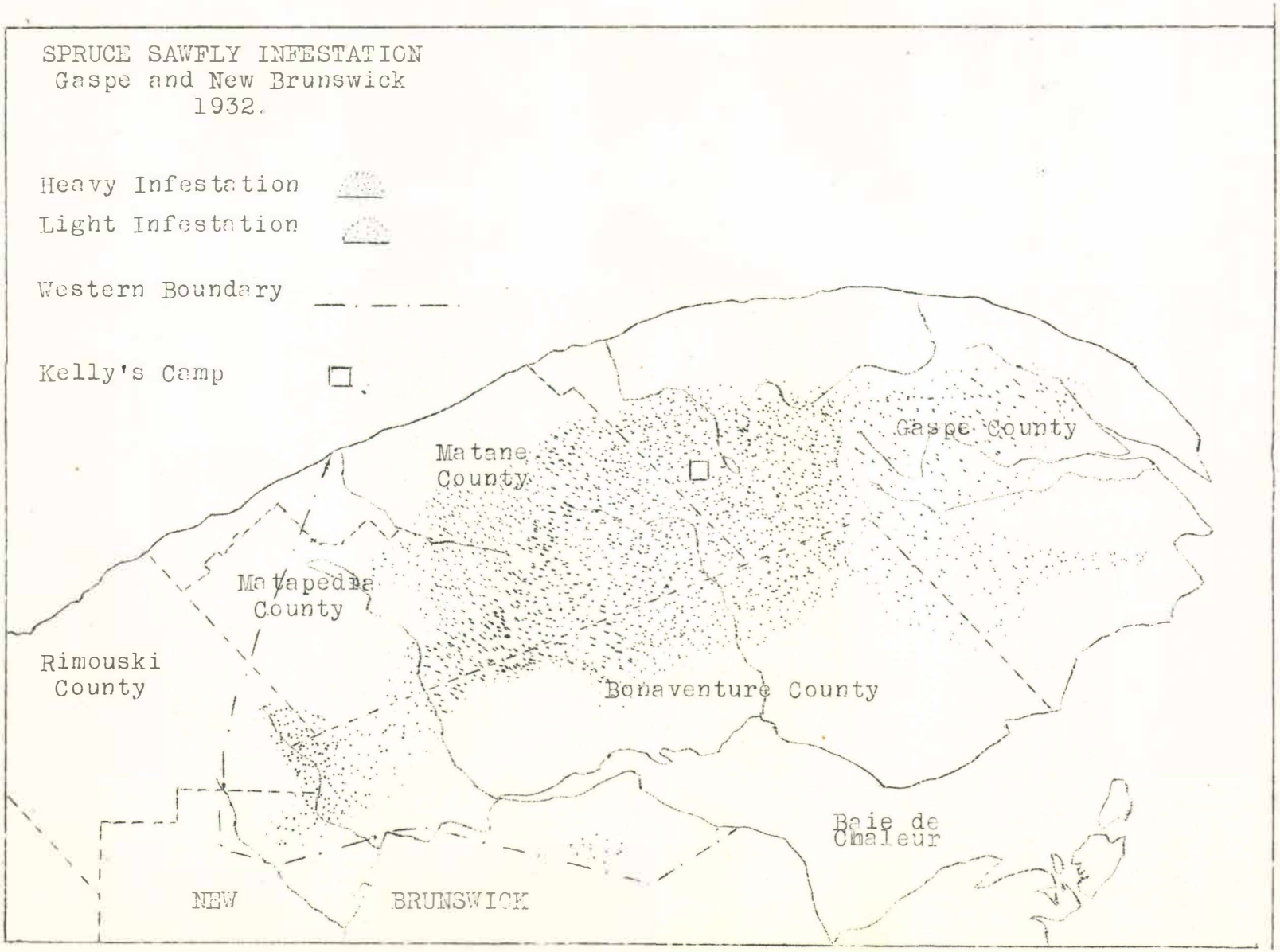
On the other hand, the annual increment has been rather seriously reduced and the last three rings are generally very small at D.B.H. in the heavily defoliated trees. In some trees considerable areas of the cambium near the base did not form any wood at all this year. Although the trees have not yet been killed, except when attacked by barkbeetles, they have been seriously weakened.

It appears, then, that this outbreak has been in operation some five or six years but the numbers have never been great enough to cause destruction of new foliage. The trees have therefore been able to manufacture sufficient food with the new foliage to continue living. They are much reduced in vigour but most of them seem capable of recovery if no further attack by sawfly or barkbeetles were to take place.

THE AREA INFESTED. The sawfly is present throughout the spruce stands of the peninsula although the numbers vary with the type of stand and are greatest in the interior, where the largest areas of virgin timber are to be found. It has been found doing important damage as far west as the Patapedia River, on the northern boundary of New Brunswick. It is also present in small numbers on the Kedgwick River and at a point just south of Campbellton. Mr. Tessier, of the Quebec Forest Service, reports that he collected cocoons south of Riviere du Loup on the western boundary of Temiscouata County. It may be present in inconspicuous numbers in other parts of Quebec and New Brunswick but the western boundary of the infestation, as far as we know it definitely, is represented by the line on the accompanying map.

Within the heavily infested area the white spruce, particularly the mature stands on the valley bottoms and lower slopes, has been most uniformly and heavily attacked. Black spruce, however, has also suffered serious loss of foliage, amounting to nearly all of the old needles on a good deal of the area. The number of insects in many black spruce stands is now greater than in the white spruce, owing, perhaps, to better hibernating conditions in the moss and to the large number of barkbeetle-killed trees in the white spruce. The black spruce, however, has been less uniformly attacked and in general has suffered more on the slopes than the flats. Many of the latter stands are only very slightly injured while on the higher slopes, even up to the tops of mountains, where the trees are stunted by exposure and do not grow over five or six feet, nearly all the old foliage has been eaten.

DAMAGE. Apart from the loss of growth and vitality, the actual loss up to the fall of this year consists almost entirely of spruce which has been killed by the barkbeetle, Dendroctonus piceaperda Hopk. It has been impossible to make an extensive study


SPRUCE SAWFLY INFESTATION
Gaspe and New Brunswick
1932.
Heavy Infestation
Light Infestation
Western Boundary
Kelly's Camp
Matane County
Gaspe County
Matapedia County
Rimouski County
Bonaventure County
Baie de Chaleur
NEW
BRUNSWICK

of this but we have estimated the conditions in the Berry Mountain Brook area by running strip cruises across the valleys. It is considered from observations over the area as a whole that conditions on this drainage are more or less similar to those throughout the heavily infested area.

Merchantable Stand: These lines were run directly across the valley as far up the slopes on both sides as the merchantable timber extended. Roughly speaking, this area coincided with the area in which white spruce grows, as the upper inacessible slopes are covered mostly with black spruce and balsam. The data, therefore, are intended to describe conditions as they would apply if a cutting operation were under consideration. It was possible to measure only 21.626 acres but the uniformity of the results indicate that they offer a fair basis for estimate. Seven thousand, nine hundred and twelve trees were tallied. The figures have been worked up by volume through the assistance of the N.B. International Paper Company. No corrections have been made for defect.

The stand consists of white spruce, black spruce, balsam, and birch. The large white spruce are found mostly in the bottom of the valley or on the lower slopes, with some black spruce and balsam intermixed. As you go up the slopes the percentage of balsam increases and the steeper slopes often are covered with pure black spruce. The percentage composition of the merchantable area, omitting the birch was as follows:

COMPOSITION OF MERCHANTABLE SOFTWOOD STAND

	White Spruce	Black Spruce	Balsam
By number of trees	21.3%	7.5%	71.2%
By volume	34.4%	7.5%	58.2%

The average merchantable softwood stand per acre, including spruce recently killed by barkbeetle but omitting birch and dead balsam, averaged 32.8 cords (5" D.B.H. and over).

In the following table the percentages of the merchantable spruce, living, killed by barkbeetle in the last two or three years, and dead apparently from sawfly attack alone are given:

MORTALITY IN MERCHANTABLE STAND

	Living.	% Killed by Barkbeetle.	% Dead Without Barkbeetle.
		White Spruce	
By number of trees	81.3	16.3	2.6
By volume	70.0	27.8	2.2
		Black Spruce	
By number of trees	90.0	8.9	1.1
By volume	85.0	14.3	0.7

It will be seen that the barkbeetle has taken the larger trees. Fifty-six per cent of the trees killed were attacked this year, showing that the barkbeetle numbers have increased considerably.

Whole Forest: In addition to the above, ten lines were run across the valley from the upper limits of the slopes including both merchantable and unmerchantable stands. The following figures show the results using only trees of 5" D.B.H. and over: 8,937 trees were tallied on 22.09 acres.

COMPOSITION OF FOREST

	% White Spruce	% Black Spruce	% Balsam	% Birch
By number of trees	12.2	7.4	72.6	7.8
By volume	20.3	7.4	62.5	9.8

Average stand per acre: 37.4 cords.

PERCENTAGE MORTALITY IN WHOLE FOREST

	% Living.	% Killed by Barkbeetles.	% Dead Without Barkbeetles.
White Spruce			
By number of trees	86.1	9.9	4.0
By volume	75.0	20.5	4.5
Black Spruce			
By number of trees	94.7	2.7	2.6
By volume	92.1	5.4	2.5

As would be expected, the percentage mortality in the whole forest is much less owing to the fact that the dead trees are practically all on the merchantable area. The percentages of dead without barkbeetle may not all have been killed by the sawfly. Some of these trees may have been weakened by other causes and the sawfly may have been a minor factor in their death.

In the figures for composition it should be noted that birch is included. They show that the white spruce is concentrated almost entirely in the lower, merchantable stands.

Valley Bottoms. The large white spruce occurs mostly on the better sites at the bottoms of the valleys. These are the most profitable stands to operate owing to their high yield per acre and proximity to streams. It is here that the chief damage is being done by the barkbeetle.

In six study plots located in this type the following mortality has already occurred:

PERCENTAGE DEAD

	of White Spruce	of Black Spruce
By stems	54.5	30.3
By volume	81.5	50.8

These figures must not be taken as an estimate of the percentage mortality throughout the whole area but they indicate how serious it is in the more heavily attacked stands.

Mr. E. B. Watson in his study of the barkbeetle this summer tallied some 3,000 spruce along the heavily infested parts of the Berry Mountain Brook. The most heavily damaged area was deliberately chosen and the trees were recorded as they came. The purpose was to discover the trend of the outbreak. The following is a summary of his results.

PERCENTAGE MORTALITY

	Living	Killed by Barkbeetle Attack 1930 and Previous	1931	1932
By number of trees	54.48	7.29	13.78	24.45
By volume	36.90	10.40	22.50	30.20

Total Mortality in 1932

By number of trees	45.52%
By volume	63.10%

These figures show very clearly that there has been a progressive increase in the numbers of barkbeetles during the past three or four years, and if this should continue many stands of this type will be completely killed, as far as the spruce is concerned. It will be noticed also that in 1932 the beetles have been forced to take smaller trees owing to the larger trees having been already killed.

The percentage mortality in the different diameter classes increases steadily from 13 per cent of the 6" class to 90 per cent of the trees over 18".

Summary. The trees killed so far are the larger white or black spruce found, for the most part, in the bottoms of the valleys. The loss in many of these stands, which, owing to their high yield and proximity to streams, are the most profitable to operate, already amounts to over 50 per cent by volume.

Considered from the point of view of the merchantable timber on all the accessible slopes the loss appears less serious, as the spruce comprises only 42 per cent of the total volume. The dead spruce forms only 13 per cent of the whole stand, 58 per cent of which is balsam and will not be injured. However,

with an average stand of 33 cords per acre this loss already amounts to 4.3 cords to the acre.

Taking the whole forest to the tops of the ridges, only 28 per cent of the total stand is spruce and the dead spruce constitutes only 6 per cent of the stand.

As the mortality, however, is chiefly confined to the larger, more accessible trees, it is already serious from the point of view of a cutting operation. Owing, also, to the large area involved and the heavy stand per acre, and considering the probability of further loss during the next few years, the total present and possible future mortality is seen to be very important. On the other hand, from the point of view of the general forest cover the injury is not serious except in so far as it will decrease the percentage of spruce in favour of balsam fir.

FACTORS OF NATURAL CONTROL. The amount of feeding this year was somewhat less than last year and preliminary analysis of our data indicates that the number of living larvae overwintering this winter is, if anything, less than last winter.

The factors responsible for keeping the numbers in check are numerous. Their value fluctuates from year to year and the following summarizes conditions in 1932.

The influence of weather was more important than in 1931. Owing to the late spring and cool summer, the period of maximum emergence was delayed two or three weeks. It also seems that the number of eggs laid per female may have been reduced by cool, wet weather. In any case, the resulting late hatch of the eggs caused a number of larvae to be caught by the fall frosts before they had completed their development. Although larvae will stand six degrees of frost and perhaps more, and will continue to develop when warm weather comes, even after snow, some of them die later and others do not reach the hibernating stage before the ground becomes permanently frozen. The number reaching hibernation was reduced as much as 20 per cent in some places by this loss.

Rain storms may cause some loss in the younger stages but this did not appear important.

Birds take a number of larvae and a few adults. Predaceous insects, such as ants and stink bugs, also spiders, are of some value, but parasitic insects are strikingly absent. Only four parasitized larvae have been found out of many thousands examined. This would support the idea that the sawfly is a comparatively recent importation.

The most important single factor of

control is the destruction of the cocoon stage by shrews, and, to a lesser extent, by mice. These small mammals are very abundant throughout the Gaspe forest and evidence of their work is found in practically every sample taken. Of more than 25,000 cocoons examined about 40 per cent had been opened by shrews and mice.

Another 15 per cent of these cocoons had been destroyed by other agencies which included predaceous insects, unfavorable conditions in the ground, and possibly disease.

Although these factors in the aggregate have kept the numbers from increasing with great rapidity, no one of them offers in itself a reliable check. The absence of parasites is particularly important. Without them the reduction of numbers must apparently be brought about chiefly by the work of shrews aided by unfavorable weather and possibly by a general drop in the fecundity of the adults.

FUTURE OF THE OUTBREAK. Definite prophesy is impossible with so many factors operating which cannot be measured in advance, especially in the case of a previously unstudied insect. Two fairly distinct probabilities, however, appear. First, the outbreak will continue. Second, it will probably continue in somewhat reduced numbers.

These probabilities are based on the assumption that the behaviour of the sawfly and its controlling factors will not vary greatly from the past two years. On the one hand it must be noted that this fall 25 per cent of the total cocoons contained living insects, as against 18.5 per cent which had produced flies. There were, therefore, more potential sawflies than had already caused the existing defoliation. If, for some reason, the percentage of emergence (which has been unusually low, about 15 per cent) should increase next year, there may be a distinct increase in the attack. This is possible but not expected.

On the other hand, a decrease in the percentage of emergence is not impossible and at the same time there may be an increase in the numbers or activity of the shrews, coupled with another unfavorable season, and perhaps a decrease in the reproductive capacity of the adults.

Our figures given above indicate that the present number of trees attacked by barkbeetles will be increased by further attack next year. Mr. Watson reports that no controlling factors have yet appeared which suggest a cessation of the barkbeetle outbreak.

Extensive mortality, outside of those trees attacked by the barkbeetle, would not be expected if the sawfly outbreak ended this year. The black spruce stands might not suffer

serious mortality from another attack similar to that of 1932. The mature white spruce stands, however, appear more seriously weakened and their ability to recover more questionable.

CONTROL AND SALVAGE. Our experiments show that calcium arsenate dust will kill the larvae, but dusting operations are not possible under present circumstances.

Control by natural methods seems to be the only possibility at the present time. The almost complete failure of native parasites to attack the sawfly is a strong argument for the introduction of species from areas where the sawfly is apparently under control. This possibility is being investigated in Europe.

Where it is economically possible to operate in the mature white spruce stands in the infested area they should be cut as a salvage operation.